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AQUATIC MACROINVERTEBRATE SURVEY OF THE BLACKFOOT RIVER, MONTANA

AUGUST, 1988 AND 1989

prepared for the
Montana Department of Health & Environmental Sciences
Water Quality Bureau
Helena, Montana

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Summary

Perceptions of declining water quality and reduced abundance of aquatic organisms has prompted a series of aquatic resource investigations in the Blackfoot River. As a component of the Montana Water Quality Bureau's investigations, aquatic macroinvertebrates were surveyed during August, 1988 and August, 1989. In 1988, the benthic community was examined at 14 sites from the headwaters to the mouth of the Blackfoot River. These data, along with water quality, toxicity bioassay, and streamflow data were presented and interpreted by Ingman et al. (1990). Six sites were resampled in 1989 to evaluate community responses to increased stream flow and to substantiate preliminary evaluations. This report presents and evaluates macroinvertebrate data collected from selected sites in the middle and lower Blackfoot River during 1988 and 1989. The objectives of this study were to determine the biological integrity of benthic communities in these reaches, to identify the probable causes of any imbalances in those communities, to confirm conclusions drawn from the 1988 data, to look for effects of fire at stations below the North Fork and to provide a baseline for future monitoring.

The aquatic macroinvertebrates captured in 48 Hess samples were used to characterize benthic community structure and function in six riffle habitats between the Landers Fork and Ninemile Prairie. Data were evaluated for indications of environmental degradation during each year, at each site, and for the study area as a whole. When biological impacts were detected, further analyses provided an estimate of the severity and probable cause(s) of the impact.

The middle reaches of the Blackfoot River supported a diverse and dynamic macroinvertebrate assemblage that was generally indicative of good water quality. However, drought-induced impacts were evident throughout the study area during 1988. The cumulative effects of several years of drought influenced species composition and reduced the structural and functional integrity of the benthic community. Elevated water temperatures and increased suspended organic matter concentrations clearly influenced the aquatic community. Impact severity varied as a function of the physical, hydrological and water quality characteristics at each site. Drought-related impacts were most severe below the confluences of the Landers Fork and Nevada Creek. Following higher stream flows in 1989, environmental stress was reduced throughout the study area. In August, 1989, macroinvertebrate assemblages were more complex, included more species and exhibited fewer indications of water quality degradation than during the previous year. The importance of adequate stream flows and periodic flushing flows in maintaining healthy aquatic communities was evident.

More persistent forms of environmental degradation were detected at several stations. The most serious impact was from nonpoint source pollution originating in the Nevada Creek basin. Although impacts were significantly reduced in 1989 compared to 1988, nutrient enrichment, sedimentation and elevated water temperatures continued to influence the aquatic community in this stream reach. Similar, but less severe impacts were indicated below the confluence of Monture Creek. In addition, limited habitat diversity and sedimentation affected the benthic community in the low gradient, depositional reach at the Nevada-Ogden Road Bridge.

Table of Contents

Summary i

List of Tables iv

List of Figures v

1. Introduction 1
2. Methods 2
3. Results and Discusion 3
4. Conclusions 21
5. Literature Cited 22

Appendices 24

- A. Aquatic macroinvertebrates collected from the Blackfoot River, Montana during August, 1988 and 1989.
- B. Blackfoot River macroinvertebrate data for August, 1989.
- C. Statistical analyses (two-way ANOVAs and Newman-Keuls tests) of selected macroinvertebrate indices for six stations on the Blackfoot River during August, 1988 and 1989.
- D. Percent Community Similarity Coefficients (Whittaker 1975) for six stations on the Blackfoot River during August, 1988 and 1989.

List of Tables

page

Table 1. Blackfoot River macroinvertebrate monitoring station descriptions. 13

Table 2. Mean values of selected indices characterizing macroinvertebrate assemblages in the Blackfoot River during August, 1988 and 1989. 14

List of Figures

page

Figure 1. Locations of monitoring stations in the Blackfoot River Basin. 12

Figure 2. Mean macroinvertebrate density (per square foot sample) at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4). 15

Figure 3. Mean taxa richness (taxa per sample) at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4). 16

Figure 4. Mean EPT richness (mayfly, stonefly and caddisfly taxa per sample) at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4). 16

Figure 5. Mean Shannon diversity at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4). 17

Figure 6. Mean biotic index values at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4). 17

Figure 7. Mean percent relative abundance of the numerically dominant macroinvertebrate taxon at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4). 18

Figure 8. Mean percent relative abundance of filter-feeding macroinvertebrates at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4). 18

Figure 9. The number and ordinal distribution of macroinvertebrate taxa collected from six sites on the Blackfoot River during August, 1988 and 1989. 19

Figure 10. Relative abundance of aquatic insect orders at six locations in the Blackfoot River during August, 1988 and 1989. 20

Introduction

Concern that the trout fishery and water quality in the Blackfoot River have declined in recent years has prompted a series of water quality and aquatic resource investigations (Ingman et al. 1990, Peters 1990, Pierce and Peters 1990, Peters and Spoon 1989). Aquatic macroinvertebrates were surveyed during August, 1988 and August, 1989 as a component of the Montana Water Quality Bureau's (WQB) investigations. Water quality, toxicity bioassay, streamflow and the 1988 macroinvertebrate data were presented and interpreted by Ingman et al. (1990). Persistent metal pollution in the upper eight to twelve miles of the Blackfoot River was the most acute water quality problem in the drainage. Water quality and biological conditions were considered good to excellent downstream from the confluence of the North Fork. In the middle reaches of the river, sediment, nutrients and the influences of an extended drought caused subtle stresses in the benthic community. At some of these sites, impacts appeared to be seasonal and transient in nature; consequently, the severity of the impacts and the processes involved were not well understood. Additional sampling in the middle reaches of the Blackfoot River was recommended as a means of providing more information about nonpoint source impairment. Based on these results, six stations were selected for further study during August, 1989.

The aquatic macroinvertebrates include immature insects, mollusks, crustaceans, worms and others. Insects, such as stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), true flies (Diptera), and beetles (Coleoptera), predominate in most streams. These organisms comprise an integral component of aquatic communities and represent an energy link between algae, organic inputs to the stream and fish. Macroinvertebrates are good indicators of water quality because they have limited mobility, relatively long life spans and are quite sensitive to many forms of environmental degradation. Macroinvertebrates are affected by chemical variables, habitat structure, sediment deposition, food sources, streamflow regime and biotic interactions. The structure and composition of the macroinvertebrate assemblage reflects the sum of environmental conditions in a stream during the past few months, and to a lesser extent, years.

This report presents and evaluates the macroinvertebrate data from six stations during August of 1988 and 1989. The two years were marked by large variations in streamflow, thus providing a good opportunity to document biological characteristics following both extremely low and unusually high flow regimes. Differences between years were used to delineate effects of the sustained drought from other sources of impairment and to document improvements resulting from scouring flows and a return to a more typical flow pattern. In addition, these data should also be useful as a baseline for detecting and gauging future impacts under a wide range of discharge patterns.

Further objectives of this study were to determine the biological integrity, or health, of benthic communities at selected sites in the Blackfoot River and to identify the probable causes of any imbalances. Biological integrity has been defined as "the capability of supporting and maintaining a balanced, integrated, adaptive community having species composition, diversity and functional organization comparable to that of natural habitat of the region" (Karr and Dudley 1981).

Methods

The methods employed during this investigation were unchanged between years and, along with study design rationale, site descriptions and supporting information, have been previously described (Ingman 1988, Ingman et al. 1990). A supplement to the methods used in the macroinvertebrate survey follows.

Field work

Benthic macroinvertebrates were collected by the WQB on August 10-11, 1988 and again on August 10, 1989 at six locations between the confluence of the Landers Fork and Ninemile Prairie (Figure 1). Site descriptions are provided in Table 1. Four quantitative samples were collected at each station on each date. The sampler was a "Hess type" with a one square foot diameter and 0.45 mm (.018 in.) mesh netting.

Laboratory work

In the laboratory, samples were stained with rose bengal dye and macroinvertebrates were separated from debris by experienced personnel. Samples from station 7 were subsampled. Subsampling was accomplished by dividing the material into equal portions (quarters or eighths) while suspended in a U.S. Standard No. 30 sieve. Two randomly selected portions were then combined to form the subsample (half or quarter of the original sample). A qualitative search for rare taxa in the unpicked portion of the sample was conducted by an experienced entomologist. Identifications were to the lowest practical level, usually genus or species. Most of the taxa identified during this study are included in a reference collection maintained by the WQB. Additional specimens were curated in Dan McGuire's personal collection and are available for review.

Data analysis

A variety of analysis techniques were used to evaluate environmental conditions in the Blackfoot River. Community structure and function were characterized for each sample and station using seven indices. Each parameter provided a different measure of the benthic community. Since macroinvertebrates exhibit different responses to various types of environmental stress, some parameters were better estimators of organic enrichment while others were more sensitive to sediment deposition or toxic pollutants. By analyzing several indices, the reliability and sensitivity of the overall evaluation was enhanced. The indices used in this analysis were:

macroinvertebrate density,
taxa richness,
Shannon diversity (Weber 1973),
biotic index (Hilsenhoff 1987, McGuire 1988, Rades 1988),
EPT richness (Plafkin et al. 1988),
percentage relative abundance of the dominant taxon (Plafkin et al. 1988), and
percentage relative abundance of filter feeders.

Statistical comparisons of these parameters among stations and between years were made using a two-way analysis of variance (ANOVA) and Newman-Keuls multiple range test (Zar 1974).

Faunal composition was compared between stations and years using Percent Community Similarity Coefficients (Whittaker 1975) and the distributions of individuals among insect orders (ordinal relative abundance). In addition, the environmental tolerances of numerically dominant taxa and unique taxa at each station were evaluated.

Results and Discussion

A checklist of aquatic macroinvertebrates collected during this survey (Appendix A), the 1989 raw data, values of indices used to characterize macroinvertebrate collections, and descriptive statistics (Appendix B), statistical analyses (Appendix C) and Percent Community Similarity Coefficients (Appendix D) are appended to this report. To facilitate their use as a baseline for future studies, Appendix B contains taxon and index values for each sample, for all replicates combined, and station means and standard deviations.

Community structure

Quantitative characterizations of community structure and function revealed significant differences (P = 0.05) among stations and between years (Appendix C). For all parameters, differences between years indicated increased biological integrity during August, 1989 (Table 2). Following high stream flows and relief from the multiple-year drought, environmental stress was reduced throughout the middle reaches of the Blackfoot River. The rationale for, and an interpretation of each index are presented below.

Macroinvertebrate density

Density estimates, although imprecise, can be a useful indicator of general environmental condition. In the absence of toxic substances, total macroinvertebrate density is influenced primarily by food supply, habitat quality and stream discharge (Hynes 1970). Organic enrichment can increase macroinvertebrate density above background levels and the magnitude of the increase can be used to gauge the significance of the pollution. Nutrient enrichment usually has a similar, but less direct impact on macroinvertebrates by stimulating plant and bacterial growth. Macroinvertebrate density may be reduced by other factors, including toxic pollutants, sediment deposition and unstable substrates.

The Blackfoot River supported a large number of insects during August, 1988 (Table 2). For all stations combined, total macroinvertebrate density averaged approximately 2,500 organisms per square foot sample (27,000 m^2) and ranged from approximately 700 to 5,000 organisms per sample (7,000 to 56,000 m^2). Densities were highest at station 4 and lowest at station 6 (Figure 2). High macroinvertebrate densities below the Landers Fork, Nevada Creek and Monture Creek indicated organic and/or nutrient enrichment (stations 4, 7 and 9, respectively).

Macroinvertebrate density declined by 38% in 1989, to an average of 1,600 organisms per sample (17,000 m^2). Overall macroinvertebrate density was significantly higher in August, 1988 than on the same date in 1989. An ANOVA of (ln x) transformed data resulted in a significance value of 0.02 with significant interactions between location and year (Appendix C). From 1988 to 1989, density was reduced at four of six stations (Figure 2). Significant reductions below the Landers Fork and Monture Creek suggested that organic loading, nutrient assimilation and temperature were increased during the 1988 drought and that high densities at these sites were primarily attributable to drought-induced eutrophication. This was not the case at stations bracketing Nevada Creek (stations 6 and 7, respectively) where more persistent biological impairment was indicated. At station 6, consistently low macroinvertebrate density during both years of this investigation and in 1971 and 1972 (Spence 1975 and summarized in Ingman et al. 1990) were attributed to poor habitat in this depositional reach. Below Nevada Creek, persistent organic and nutrient enrichment were indicated by high macroinvertebrate density during 1988 and 1989. Macroinvertebrate density was significantly higher at station 7 than at stations 6 and 12.

Taxa richness

The number of macroinvertebrate species, or taxa richness, is probably the best indicator of toxic pollution and microhabitat diversity since the loss of the "most sensitive taxa" will decrease taxa richness. Taxa richness is less sensitive to mild organic and nutrient enrichment. Based on previous investigations of the Blackfoot and other western Montana rivers (summarized in Ingman et al. 1990), heterogeneous habitats with good water quality typically yield taxa richness values of 35 or more per sample. Since taxonomic consistency is required for meaningful comparisons between studies, it is advantageous to report the number of mayfly, stonefly and caddisfly taxa (EPT richness).

Total and EPT taxa richness were high at all sites (Table 2) and indicated the absence of severe pollution throughout the study area. Mean taxa richness (Figure 3) ranged from 33 to 50 taxa per sample while EPT richness (Figure 4) varied from 17 to 25 taxa per sample. Both measures were significantly higher in 1989 than in 1988 (Appendix C) which suggested that environmental stress was broadly reduced during 1989. For both years combined, taxa richness was significantly higher at stations 7, 8 and 12 than at stations 4, 6 and 9.

Shannon diversity

Shannon diversity is a widely used index of environmental condition. It was originally developed as a measure of organic pollution but does respond to other forms of environmental stress. Based on studies of the Bitterroot and Clark Fork rivers (Kerr 1988 and McGuire 1991, respectively), diversity values above 3.4 are associated with excellent environmental condition in western Montana rivers while slight, moderate and severe stress are indicated by values of 2.8 to 3.3, 2.2 to 2.7 and less than 2.1, respectively.

With the exception of the station 4 during 1988, diversity was high and indicative of good to excellent environmental condition at all stations (Table 2). During August, 1988, severe environmental stress was indicated by the imbalanced macroinvertebrate assemblage below the Landers Fork while slight stresses were suggested at stations above Nevada Creek, below Nevada Creek and below Monture Creek. From 1988 to 1989, Shannon diversity increased at all stations (Figure 5). Mean diversity in 1989 (3.7) was significantly higher than in 1988 (3.1)

Biotic index

The biotic index was developed to detect organic pollution and is based on the indicator organism approach to water quality assessment. The index is on a scale of 0 to 10 with higher values indicating more polluted conditions. With regard to organic pollution, Hilsenhoff (1987) used seven categories of water quality ranging from excellent (<3.5), through very good (3.6 to 4.5), good (4.6 to 5.5), fair (5.6 to 6.5), fairly poor (6.6 to 7.5), poor (7.6 to 8.5), to very poor (>8.5).

The composite biotic index for stations in this reach of the the Blackfoot River was 4.5 during August, 1988 and 4.1 during August, 1989. The overall biotic index was significantly lower in 1989 than in 1988; however, both values indicated very good water quality with only minor degradation due to organics. The most significant improvement between years was below the confluence of the Landers Fork (Figure 6). In August, 1988, water quality was classified as excellent at the Nevada Creek control site, very good at Ninemile Prairie and good at the four other stations. During 1989, biotic index values were categorized as excellent at the two stations above Nevada Creek, good at stations from Nevada Creek to Monture Creek, and very good from Monture Creek to Ninemile Prairie.

Percent relative abundance (PRA) of the numerically dominant taxon

The relative abundance of the numerically dominant taxon was used as a simple measure of equitability. The conceptual basis for the index is that stressed environments will have communities dominated by a few taxa and the most abundant taxon will comprise a large percentage of the fauna. The empirical scale used to evaluate these data is slightly less rigorous than that developed by the U. S. EPA for 100 organism kick samples (Plafkin et al. 1988). For this evaluation, PRAs less than 30% indicated an unstressed community while abundances from 30 to 40%, 40 to 50% and greater than 50%, respectively, indicated slight, moderate and severe environmental stress.

This metric indicated significant reductions in environmental stress between years (Appendix C) with the average relative abundance of the dominant taxon declining from 39% in 1988 to 26% in 1989. Environmental stress was indicated at four sites during 1988 and one station in 1989 (Figure 7). In 1988, stress was most evident at stations 4, 6 and 7, above the confluence of the North Fork. Subsequent improvement, as measured by reduced relative abundance of the dominant taxon, was most evident at these sites. Slight stress was indicated below Monture Creek during both years.

Percent relative abundance of filter feeders

The relative abundance of various functional feeding groups (filterers, scrapers, shredders, etc.) can provide useful insights into energy transfer, organic loading and toxic conditions. The importance of each functional group varies with season. During the summer, filterers usually comprise a major component (20 to 50%) of the benthic fauna in large rivers. Relative abundances greater than about 50% indicate high levels of suspended organic matter which are usually associated with organic/nutrient enrichment or lake outflows.

For all stations combined, the mean relative abundance of filter feeding macroinvertebrates was 42% in 1988 and 26% in 1989. The percentage of filterers declined at all stations in 1989 with the greatest reductions below the Landers Fork and Nevada Creek (Figure 8). In 1988, localized organic/nutrient enrichment was indicated by the predominance of filterers at these sites. These localized impacts could have been accentuated by extensive algal and bacterial growth associated with low flows and high water temperature. At station 6, which is located between these two stations, filterers comprised a small percentage of the fauna during both years.

Community composition

The study area supported a large and varied assemblage of macroinvertebrates. Individual sites yielded 45 to 70 taxa on each date sampled and a total of 127 macroinvertebrate taxa were identified from the six stations (Appendix A). More taxa were collected in 1989 than in 1988 (95 versus 118, respectively). Dipterans accounted for more than one third of genera present. The remaining taxa consisted of caddisflies, mayflies, stoneflies, beetles and others (Figure 9).

Ordinal relative abundance

Insects comprised approximately 99% of the aquatic macroinvertebrates collected. In August, 1988, dipterans accounted for 41% of the fauna while mayflies and caddisflies each comprised 24%. The following year, mayfly relative abundance increased to 41% while the percentage of dipterans and caddisflies declined to 28 and 18%, respectively. Among stations, the distribution of major taxonomic groups exhibited similar patterns during both years (Figure 10). At the four stations downstream from Nevada Creek, dipterans, mayflies and caddisflies were codominant; however, at stations above Nevada Creek, caddisflies were a minor faunal component. Dipterans, particularly black flies, were extremely abundant below the Landers Fork during 1988, while in 1989, dipterans and mayflies were both relatively abundant. The fauna at the Nevada-Ogden Road Bridge (station 6) was quite different then at all other sites. During both years, mayflies predominated at this site and stoneflies attained their greatest relative abundances.

Community similarity

The Percent Community Similarity (PCS) coefficient provided a quantitative comparison of faunal composition for each possible station pairing. Stations with similar faunas have high coefficients (> 50) while sites with different habitat or water quality usually support dissimilar faunas which result in low coefficients (<50). During both years, similarity coefficients were higher for stations below the confluence of the North Fork than for upstream stations (Appendix D). PCS coefficients ranged from 69 (stations 8 and 12, 1988) to 19 (stations 4 and 6, 1988). The relatively low values for stations above the confluence of the North Fork reflected the varied habitats present in this reach.

Within sites, faunal similarity between years can be used to gauge the significance of changing environmental conditions. Faunal composition was similar between years for most stations with similarity coefficients exceeding 60. However, at stations below the Landers Fork and Nevada Creek, coefficients in the 40's denoted substantial shifts in community composition. Year-to-year changes in faunal composition at these sites suggested that the macroinvertebrate communities were influenced by variable environmental conditions.

Synopsis of the benthic fauna and environmental conditions

Blackfoot River between Landers Fork and Lincoln (station 4)

Good water and habitat quality were indicated at this station; however, this stream reach was extremely susceptible to drought-induced stress. In August, 1988, station 4 supported the highest macroinvertebrate densities encountered during this study, with black flies (*Simulium* s.g. *Eusimulium*) accounting for 76% of the benthic fauna. Most indices detected this imbalance and indicated severe biological impairment. Organic enrichment, probably originating in upstream beaver ponds, wetlands, and side channels had a dramatic influence on the aquatic community by augmenting the food supply during low streamflow. During drought, the water temperature and retention times in backwaters can increase, resulting in substantial algal and bacterial blooms. Subsequently, organic loading to the stream may be increased dramatically while dilution is reduced by low streamflow. Indications of organic enrichment were greatly diminished during 1989. During the second year of this study, a more balanced and diverse, but less dense insect community was present. During August, 1989, black flies accounted for 26% of the fauna and were codominant with the mayfly, *Baetis tricaudatus*, and the midge, *Micropsectra* sp.

Blackfoot River at Nevada-Ogden Road Bridge (station 6)

Good water quality but poor habitat were indicated at this site. The benthic community was substantially different than at other stations and was impaired by the deposition of fine sediments. The depositional nature of this reach was due to the low stream gradient (Peters and Spoon 1989). During both years, the heptageniid mayfly, *Rhithrogena* sp., was the most abundant of more than 50 taxa collected. Other abundant insects included *Baetis insignificans*, *Baetis tricaudatus*, *Micropsectra* sp. and chloroperlid stoneflies. The dominance of these taxa, along with the presence of numerous other taxa, indicated good water quality at this site. The relatively low density of aquatic macroinvertebrates, the low percentage of filterers and the high relative abundance of *Rhithrogena* sp. were apparent responses to the prevalence of small gravel and silt substrates. Spence (1975) found a similar fauna and low macroinvertebrate densities at this site in 1971 and 1972. Similar faunal composition and community structure during all four years suggests that variation in the flow regime has little impact on the the biota in this reach.

Blackfoot River at Helmville Br. (station 7)

A number of environmental factors contributed to an atypical and highly variable benthic fauna in this low gradient reach below the confluence of Nevada Creek. Several years of drought, extending through 1988, appeared to be the catalyst for the development of this unusual (for the Blackfoot River) biological community. During August, 1988, drought and nonpoint source pollution, including nutrient enrichment, sedimentation and relatively high water temperature, resulted in reduced structural and functional integrity of the community at this site. Evidence of an impaired benthic community included high macroinvertebrate density, biotic index, relative abundance of filterers and relative abundance of the dominant taxon. By comparison, environmental stress was significantly reduced in 1989. With the exception of total density, all measures of community structure and function showed improvement compared to 1988. Community composition also changed dramatically between years. During 1988, the fauna was dominated by caddisflies and blackflies while, in 1989, mayflies and different caddisflies were dominant. *Hydropsyche occidentalis* and *Simulium* (mostly s.g. *Psilozia*) comprised nearly 60% of the fauna in 1988 but only 10% of the total in 1989. The shift to a community dominated by *Baetis tricaudatus*, *Cheumatopsyche* sp., *Tricorythodes minutus* and *Hydropsyche tana/oslari* may have been due to the higher flow and lower temperature regimes during 1989.

During both years, community composition was strongly influenced by warm summer water temperatures and was characteristic of summer maxima above 25 C (77 F). Relative to other reaches of the Blackfoot River, elevated water temperatures have been documented from the confluence of Nevada Creek to the North Fork (Pierce and Peters 1990). The predominance of hydropsychids other than *H. tana/oslari* may be a useful indicator of temperature-stressed communities in the Blackfoot River.

Benthic habitat was characterized by cobble substrates packed with coarse sand, luxuriant growths of aquatic vegetation and accumulations of fine sediment in and around beds of vegetation. Dense mats of aquatic vegetation, absent from other sites in the Blackfoot River, had a major influence on the abundance and type of macroinvertebrates at this site. The tremendous volume and variety of habitats provided in and around the vegetation supported macroinvertebrate densities exceeding 32,000 m^2 during both years. In contrast, the total density at the five other stations averaged 26,000 m^2 in 1988 but declined to 11,000 m^2 in 1989. Some of the 72 taxa present at station 7, including *Psuedocloeon* sp., *Pentaneura* sp. and *Ophiogomphus* sp., appear restricted to habitats provided by aquatic plants. Others were favored by, or tolerant of, the fine sediments associated with the weed beds. The burrowing mayfly *Ephemera simulans*, tubificid oligochaetes, the elmid beetle *Dubiraphia*, and most midges in the tribe Chironomini are examples of organisms favored by fine substrates while silt tolerant aquatic insects include many chironomids, the caddisfly *Cheumatopsyche*, and the mayflies *Heptagenia solitaria*, *Tricorythodes minutus* and *Paraleptophlebia bicornuta*. These taxa were restricted to, or were more abundant, at this site than elsewhere in the Blackfoot River.

Blackfoot River above Monture Creek (station 8)

At station 8, a diverse and functionally complex insect fauna exhibited no signs of significant water quality or habitat degradation. The species rich insect assemblage included many taxa considered intolerant of pollution: *Micropsectra* spp., *Baetis tricaudatus*, *Hydropsyche* (C.) *tana/oslari* and *Optioservus* sp. were numerically dominate each year, comprising 63% of the fauna in 1988 and 55% in 1989. Although occurring at low densities, a variety of large, relatively pollution-sensitive species were important components of the community. These included *Pteronarcys californica*, three species of perlid stoneflies and several species each of limnephilid, hydropsychid and rhyacophilid caddisflies. The only sign of potential water quality problems was a slightly elevated biotic index.

Blackfoot River below Scotty Brown Bridge (station 9)

Located below Monture Creek, the biological integrity at this site was slightly reduced compared to other stations in the lower Blackfoot River. Nevertheless, the macroinvertebrate fauna was characteristic of fairly good water quality and habitat. During 1988, most measures of community structure indicated slight impairment due to organic enrichment (Table 1). In 1989, community structure was more balanced with total density, taxa richness, Shannon diversity, biotic index, and the relative abundance of the dominant taxon registering improved biological integrity. However, most indices remained slightly depressed compared to other stations in the lower river. Faunal composition at this site was generally similar to that at station 8. During both years, the major difference between sites was a much larger black fly (*Simulium* s.g. *Eusimulium*) population below Monture Creek than above.

Blackfoot River at Ninemile Prairie (station 12)

Although total macroinvertebrate density was relatively low at this site during both years, all parameters indicated excellent biological integrity and good environmental conditions. Consistently low macroinvertebrate density may have been attributable to the predominance of smaller substrate particles at this site. This phenomenon has previously been noted in a depositional reach near the mouth of the Blackfoot River (McGuire 1987). The numerically dominant taxa at station 12 were typical of the lower river and included *Baetis tricaudatus*, *Hydropsyche tana/oslari*, and *Micropsectra* sp. In addition, *Cheumatopsyche* sp., *Baetis insignificans* and *Zaitzevia parvula* attained fairly high relative abundances at this site. These three taxa were widely distributed, but did not attain particularly high densities in the lower Blackfoot River. At station 12, their increased relative abundance was primarily due to the low densities of other taxa rather than increased densities of these three taxa. Increased sediment deposition may be indicated at site where these taxa comprise a substantial portion of the fauna.

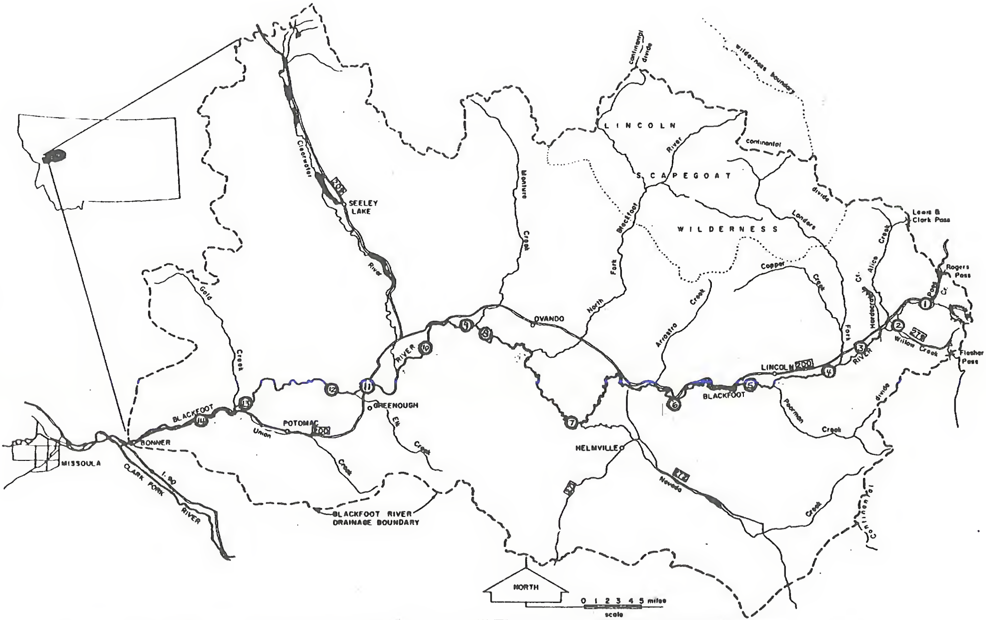


Figure 1. Location of monitoring stations in the Blackfoot River Basin. Stations are indicated by circled numbers.

Table 1. Blackfoot River macroinvertebrate monitoring station descriptions.

Site No.	Site Name	Legal Description	Location Rationale
4	Blackfoot R. between Landers Fork and Lincoln	T14N R8W Sec 22 BC	Downstream of Landers Fork
6	Blackfoot R. at Nevada-Ogden Rd. Br.	T14N R10W Sec 34 BD	Control site above Nevada Cr.
7	Blackfoot R. at Helmville Br.	T13N R12W Sec 12 AC	Downstream of Nevada Cr. Suspected agricultural impacts
8	Blackfoot R. above Monture Cr.	T15N R13W Sec 34 BA	Downstream of North Fork
9	Blackfoot R. below Scotty Brown Br.	T15N R13W Sec 32 AB	Downstream of Monture Cr.
12	Blackfoot R. at Ninemile Praire	T14N R15W Sec 28 AB	Downstream of Elk Cr. possible mining impacts

Table 2. Mean values of selected indices characterizing macroinvertebrate assemblages in the Blackfoot River during August, 1988 and 1989 (four 1.0 sq. foot samples per date at each station).

station	density 1 sq. ft.		taxa richness		Shannon diversity		biotic index		EPT richness		%RA dominant		%RA filterers	
	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989
4	5141	1065	33	36	1.7	3.6	5.5	3.4	18	20	70	27	71	24
6	653	720	33	34	3.1	3.4	2.4	3.0	19	17	40	28	8	3
7	3049	4179	36	49	3.2	3.8	5.0	4.7	19	24	40	19	63	37
8	1823	1248	37	50	3.6	4.2	4.8	4.9	19	25	26	16	29	20
9	3585	1443	34	39	3.1	3.3	5.1	4.3	17	22	33	25	43	41
12	982	717	41	44	3.9	4.1	4.4	4.2	21	22	22	23	37	30
mean	2539	1562	36	42	3.1	3.7	4.5	4.1	19	22	39	23	42	26
standard dev.	1710	1314	3	7	0.8	0.4	1.1	0.7	1	3	17	5	23	14

Figure 2. Mean macroinvertebrate density (per square foot sample) at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4).

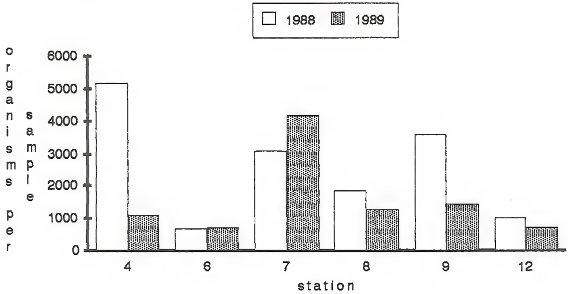


Figure 3. Mean taxa richness (taxa per sample) at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4).

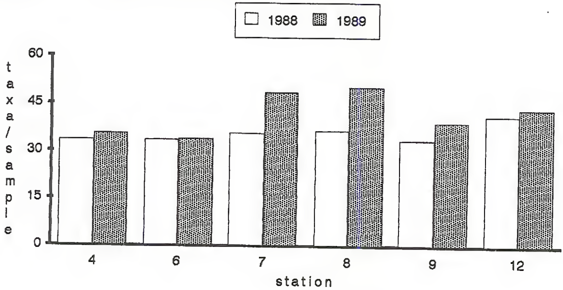


Figure 4. Mean EPT richness (mayfly, stonefly and caddisfly taxa per sample) at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4).

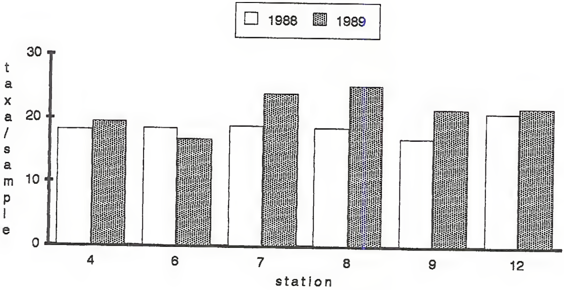


Figure 5. Mean Shannon diversity at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4).

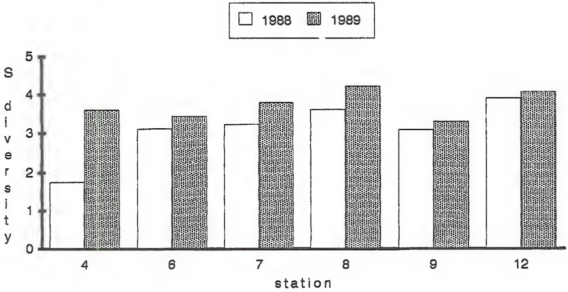


Figure 6. Mean biotic index values at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4).

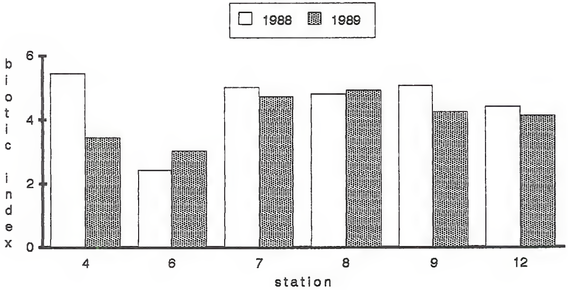


Figure 7. Mean percent relative abundance of the numerically dominant macroinvertebrate taxon at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4).

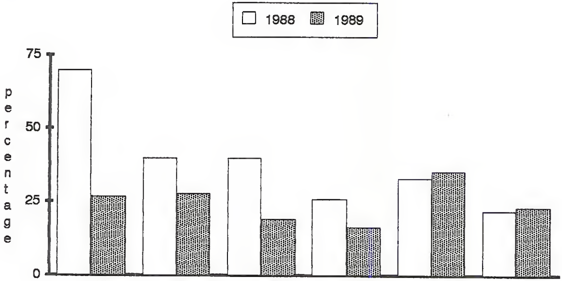


Figure 8. Mean percent relative abundance of filter-feeding macroinvertebrates at 6 stations on the Blackfoot River during August, 1988 and 1989 (n=4).

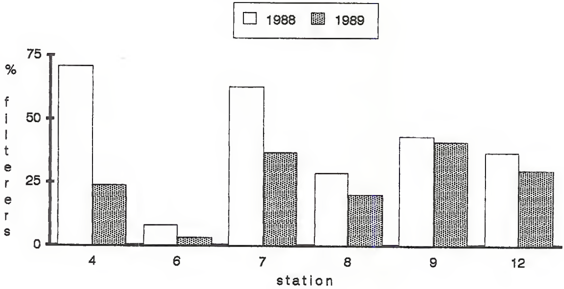


Figure 9. The number and ordinal distribution of macroinvertebrate taxa collected from six sites on the Blackfoot River during August, 1988 and 1989.

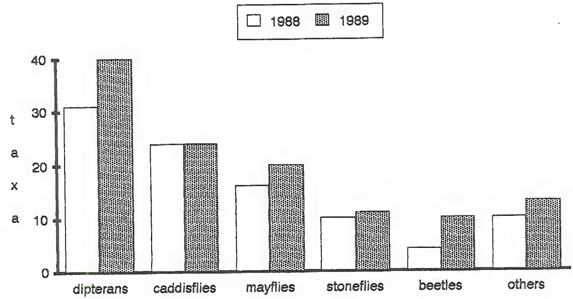
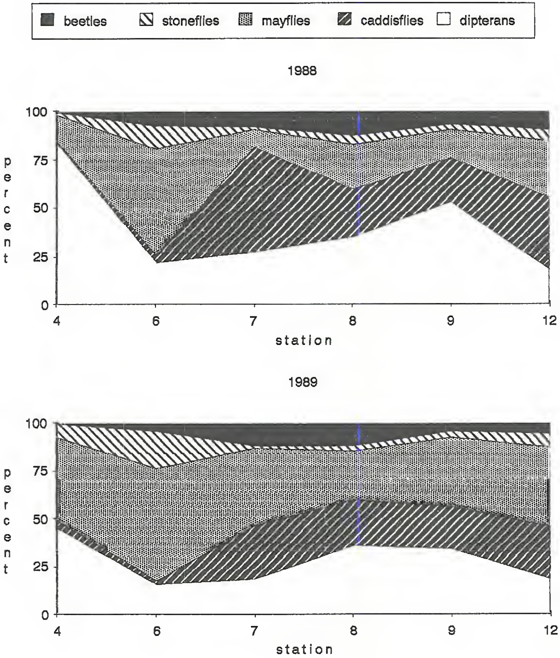


Figure 10. Relative abundance of aquatic insect orders at six locations in the Blackfoot River during August, 1988 and 1989.



Conclusions

1. The middle and lower reaches of the Blackfoot River supported a varied and dynamic macroinvertebrate assemblage that was generally indicative of good water quality. However, drought related impacts were clearly evident throughout most of the Blackfoot River during August, 1988.

2. The cumulative effects of several years of drought influenced species composition and reduced the structural and functional integrity of benthic communities throughout the study area during August, 1988. Environmental stress was indicated and the macroinvertebrate community showed clear responses to elevated water temperatures and increased suspended organic matter concentrations. Impact severity was diminished or intensified by the physical, hydrological and water quality characteristics at each site.

3. Impacts were most severe at stations 4, 7 and 9, respectively located below the confluences of the Landers Fork, Nevada and Monture creeks. The drought intensified impacts of slight to moderate organic and/or nutrient enrichment at these sites.

4. In August, 1989, macroinvertebrate assemblages were healthier, more complex and exhibited fewer indications of environmental stress than during the previous year. Impacts present in 1988 were largely alleviated in 1989, documenting the importance of flushing flows and adequate base flows in supporting healthy aquatic communities.

5. Persistent nonpoint source pollution was confirmed below the confluence of Nevada Creek during both years. Although impacts were significantly reduced in 1989 compared to 1988, nutrient enrichment, sedimentation and elevated water temperatures continued to impair the aquatic community at station 7.

6. Similar, but less severe impacts were detected below the confluence of Monture Creek at station 9.

7. Limited habitat diversity resulted in relatively low macroinvertebrate densities at the Nevada-Ogden Road Bridge site. Relatively small substrate particles and accumulations of fine sediments limited the aquatic community in this low gradient, depositional reach.

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Appendices

Blackfoot River macroinvertebrate survey

August, 1989

Appendix A. Aquatic macroinvertebrates collected from the Blackfoot River, Montana during August of 1988 and 1989 (identifications by Dan McGuire).

order	family	genus/species	1988	1989
EPHEMEROPTERA	(mayflies)			
	Siphlonuridae	*Ameletus sp.*	X	
	Baetidae	*Baetis insignificans*	X	X
		Baetis tricaudatus	X	X
		Psuedocloeon sp.	X	X
	Heptageniidae	*Cinygmula sp.*	X	X
		Epeorus albertae	X	X
		Heptagenia solitaria		X
		Nixe sp.		X
		Rhithrogena sp.	X	X
	Ephemerellidae	*Attenella margarita*	X	X
		Ephemerella inermis/infrequens	X	X
		Drunella coloradensis	X	X
		Drunella doddsi	X	X
		Drunella grandis	X	X
		Serratella tibialis	X	X
		Serratella sp.	X	X
		Timpango hecuba	X	X
	Ephemeridae	*Ephemera sp.(prob. simulans)*		X
	Leptophlebiidae	*Paraleptophlebia sp.*	X	X
		Paraleptophlebia bicornuta		X
	Tricorythidae	*Tricorythodes minutus*	X	X
DIPTERA (true flies)				
	Tipulide	*Antocha sp.*	X	X
		Dicranota sp.	X	
		Hexatoma sp.	X	X
		Rhabdomastix sp.		X
		Tipula sp.		X
		unidentified larva	X	X
	Psychodidae	*Pericoma sp.*	X	X
	Ceratopogonidae	Ceratopogoninae	X	X
	Simuliidae	*Simulium spp.*		
		(s.g. Psilozia)	X	X
		(s.g. Eusimulium)	X	X
	Athericidae	*Atherix pachpus*	X	X
	Empididae	*Chelifera sp.*	X	X
		Clinocera sp.	X	X
	Pelecorhynchidae	*Glutops sp.*	X	
	Stratiomyiidae	*Odontomyia sp.*		X
	Dolichopodidae			X

Appendix A. Aquatic macroinvertebrates collected from the Blackfoot River, Montana during August of 1988 and 1989 (identifications by Dan McGuire).

order	family	genus/species	1988	1989
DIPTERA (continued)				
	Chironomidae			
	Tanypodinae	Thienemannimyia gp.	X	X
		Pentaneura sp.	X	X
	Diamesinae	*Diamesa sp.*	X	X
		Monodiamesia sp.		X
		Pagastia sp	X	X
		Potthastia longimanus gp.	X	
		Potthastia gaeddi gp.	X	X
	Orthocladiinae	*Brillia sp.*	X	X
		Cardiocladius spp.	X	X
		Corynoneura sp	X	X
		Cricotopus spp.	X	X
		C. (Isocladius) sp., C. (Nostococladius) sp., C. (C.) bicinctus, tremelus & trifascia gps.		
		Eukiefferiella spp.	X	X
		E. brehmi, claripennis gp. devonica gps.		
		Krenosmittia sp.		X
		Lopescladius sp.	X	
		Orthocladius spp.	X	X
		O. (Ortho.) &(Euorthorthocladius.		
		Nanocladius sp.	X	X
		Paraphaenocladius spp.	X	X
		Rheocricotopus sp.	X	X
		Synorthocladius sp.	X	X
		Thienemanniella sp.	X	X
		Tvetenia sp.	X	X
	Chironominae			
	Chironomini	*Cryptochironomus sp.*	X	X
		Demicryptochironomus sp.	X	
		Microtendipes sp.	X	X
		Phaenopsectra sp.	X	X
		Polypedilum spp.	X	X
		Robackia sp.	X	
		Xenochironomus sp.	X	
	Tanytarsini	*Cladotanytarsus sp.*	X	
		Micropsectra spp.	X	X
		Tanytarsus (Sublettea) sp.		X
		Rheotanytarsus sp.	X	X

Appendix A. Aquatic macroinvertebrates collected from the Blackfoot River, Montana during August of 1988 and 1989 (identifications by Dan McGuire).

order	family	genus/species	1988	1989
TRICHOPTERA (caddisflies)				
	Philopotamidae	*Wormaldia sp.*	X	X
	Psychomyiidae	*Psychomyia sp.*	X	X
	Polycentropidae	*Crynellus sp.*	X	
	Hydropsychidae	*Arctopsyche grandis*	X	X
		Parapsyche elsis	X	
		Cheumatopsyche spp.	X	X
		Hydropsyche spp.		
		H. (Ceratopsyche) spp.	X	X
		(C.) cockerelli,	X	X
		(C.) tana/oslari?	X	X
		H. (Hydropsyche) spp.	X	X
		H. (H.) occidentalis		
	Rhyacophilidae	*Rhyacophila spp.*	X	
		R. angelita sp.	X	X
		R. betteni gp.	X	
		R. brunnea gp.	X	X
		R. coloradensis gp.	X	
		R. iranda gp.	X	
	Glossosomatidae	*Agapetus sp.*	X	X
		Culoptila sp	X	X
		Glossosoma sp.	X	X
	Hydroptilidae	*Hydroptila spp.*	X	X
		Ochrotrichia sp	X	
		Leucotrichia pictipes	X	
		Zumatrichia notosa	X	
	Brachycentridae	*Brachycentrus americanus*	X	X
		Brachycentrus occidentalis	X	X
		Micrasema sp.	X	X
	Lepidostomatidae	*Lepidostoma sp.*	X	X
	Limnephilidae	*Apatania sp.*	X	X
		Dicosmoecus sp.	X	X
		Neophylx sp.	X	X
	Helicopsychidae	*Helicopsyche sp.*	X	X
	Leptoceridae	*Ceraclea sp.*	X	X
		Oecetis sp.	X	X
LEPIDOPTERA (moths)				
	Pyralidae	*Petrophila sp.*	X	X
HEMIPTERA (bugs)				
	Corrixidae	*Sigara alternata*	X	
	Saldidae			X
ODONATA (dragonflies)				
	Gomphidae	*Ophiogomphus sp.*	X	X

Appendix A. Aquatic macroinvertebrates collected from the Blackfoot River, Montana during August of 1988 and 1989 (identifications by Dan McGuire).

order	family	genus/species	1988	1989
COLEOPTERA (beetles)				
	Dytiscidae	*Hydrochus sp.*		X
		Oreodytes sp.		X
	Elmidae	*Cleptelmis ornata*	X	X
		Dubiraphia sp.		X
		Heterlinnius corpulentus	X	
		Lara avara	X	
		Narpus concolor	X	X
		Optioservus spp.	X	X
		Stenelmis sp.	X	X
		Zaitzevia sp.	X	X
	Haliplidae	*Brychius sp.*	X	
	Heteroceridae			X
	Staphylinidae			X
PLECOPTERA (stoneflies)				
	Perlidae	*Calineuria californica*	X	X
		Claassenia sabulosa	X	X
		Hesperoperla pacifica	X	X
	Perlodidae	*Cultus sp.*	X	
		Isogenoides sp.	X	
		Skwala sp.	X	X
		Isoperla sp.		X
	Chlloroperlidae	*Chloroperlinae*	X	X
		Kathroperla sp.	X	
	Nemouridae	*Amphinemura sp.*	X	X
		Zapada cinctipes	X	X
		Zapada sp.		X
	Capniidae	*Capnia gp.*	X	
	Pteronacidae	*Pteronarcella badia*	X	X
		Pteronarcys californica	X	X
ANNELIDA				
Oligochaeta	Enchytraediae		X	
	Lumbricidae		X	X
	Lumbriculidae		X	X
	Naididae			X
	Tubificidae		X	X
Hirudinea	Erpobdellidae			X
	Glossiphoniidae			X
MOLLUSCA				
Gastropoda				
	Lymnaeidae		X	X
	Planorbidae	*Gyraulus sp.*	X	
	Physidae		X	X
	Ancyclidae	*Ferrissia sp.*	X	
Pelecypoda	Sphaeriidae		X	X
TURBELLARIA			X	X

Appendix B:

Blackfoot River macroinvertebrate data for August, 1989

MACROINVERTEBRATE DATA

BLACKFOOT RIVER between Landers Fork & Lincoln -STATION 4 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
COLEOPTERA						0%	3	
Optioservus spp.	1	0	2	6	9	0%	2.3	2.6
Zaitzevia parvula	1	0	0	1	2	0%	0.5	0.6
Hydrochus sp.	1	0	1	0	2	0%	0.5	0.6
DIPTERA						46%	490	
Thienemannimyia gp.	15	3	13	8	39	1%	9.8	5.4
Diamesa spp.	6	4	5	4	19	0%	4.8	1.0
Pagastia sp	4	0	4	0	8	0%	2.0	2.3
Brillia sp.	0	0	1	0	1	0%	0.3	0.5
Eukiefferiella spp.	38	3	15	15	71	2%	17.8	14.6
Krenosmittia sp.	2	0	0	0	2	0%	0.5	1.0
Orthocladius spp.	0	0	1	2	3	0%	0.8	1.0
Paraphaenocladius sp.	7	4	20	5	36	1%	9.0	7.4
Rheocricotopus sp.	0	3	6	3	12	0%	3.0	2.4
Tvetenia sp.	64	9	36	34	143	3%	35.8	22.5
Micropsectra spp.	183	38	186	84	491	12%	122.8	73.7
Hexatoma sp.	0	1	3	1	5	0%	1.3	1.3
Rhabdomastix sp.	0	1	1	2	4	0%	1.0	0.8
Simulium spp. (Eusimuluin	152	28	647	265	1092	26%	273.0	267.5
Pericoma sp.	0	1	0	2	3	0%	0.8	1.0
Clinocera sp.	6	0	9	3	18	0%	4.5	3.9
Chelifera sp.	4	2	1	4	11	0%	2.8	1.5
Dolichopodidae	0	0	1	0	1	0%	0.3	0.5
EPHEMEROPTERA						43%	455	
Baetis insignificans	2	0	0	3	5	0%	1.3	1.5
Baetis tricaudatus	230	103	141	132	606	14%	151.5	54.8
Attenella margarita	4	0	1	4	9	0%	2.3	2.1
Serratella spp.	85	43	88	70	286	7%	71.5	20.6
Drunella coloradensis	10	14	10	16	50	1%	12.5	3.0
Drunella doddsi	69	16	42	68	195	5%	48.8	25.2
Drunella grandis	0	0	1	0	1	0%	0.3	0.5
Cinygmula sp.	22	17	16	15	70	2%	17.5	3.1
Epeorus albertae	66	54	50	44	214	5%	53.5	9.3
Rhithrogena sp.	119	32	65	167	383	9%	95.8	59.5
Tricorythodes minutus	1	0	0	0	1	0%	0.3	0.5
PLECOPTERA						7%	78	
Hesperoperla pacifica	3	1	5	0	9	0%	2.3	2.2
Amphenimora sp	0	0	1	0	1	0%	0.3	0.5
Zapada cinctipes	49	5	44	31	129	3%	32.3	19.7
Zapada sp.	0	0	1	0	1	0%	0.3	0.5
Cultus sp.	0	1	2	0	3	0%	0.8	1.0
Skwala parallela	0	1	0	0	1	0%	0.3	0.5
Pteronarcella badia	5	0	3	3	11	0%	2.8	2.1
Chloroperlinae	47	22	47	41	157	4%	39.3	11.8

MACROINVERTEBRATE DATA

BLACKFOOT RIVER between Landers Fork & Lincoln -STATION 4 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
TRICHOPTERA						4%	38	
Arctopsyche grandis	29	6	29	26	90	2%	22.5	11.1
Cheumatopsyche spp.	2	1	0	0	3	0%	0.8	1.0
H. (Ceratopsyche) spp.?	1	0	0	2	3	0%	0.8	1.0
Limnephilidae	2	0	0	0	2	0%	0.5	1.0
Brachycentrus americanus	6	1	3	0	10	0%	2.5	2.6
Rhyacophila angelita sp.	2	12	3	6	23	1%	5.8	4.5
Rhyacophila brunnea gp.	0	1	0	2	3	0%	0.8	1.0
Agapetus sp.	5	7	1	1	14	0%	3.5	3.0
Glossosoma sp.	0	1	0	1	2	0%	0.5	0.6
ANNELIDA						0%	1	
Lumbriculidae	0	1	1	2	4	0%	1.0	0.8
MOLLUSCA						0%	0	
Lymnaea sp.	1	0	0	0	1	0%	0.3	0.5
OTHER								
Turbellaria	2	0	0	0	2	0%	0.5	1.0
TOTAL ORGANISMS	1246	436	1506	1073	4261		1065	456
TAXA RICHNESS	37	32	39	35	52		36	3.0
SHAN. DIVERSITY	3.82	3.81	3.16	3.65	3.70		3.61	0.31
BIOTICINDEX	3.56	2.83	4.13	3.21	3.60		3.43	0.55
EPT RICHNESS	21	19	20	18	28		20	1.3
EPT / CHIR.	2.38	5.28	1.93	4.08	2.77		3.4	1.6
% R.A. DOMINANT	18%	24%	43%	25%	26%		27%	10.7%
% R.A. FILTERERS	15%	8%	45%	27%	28%		24%	16.1%
ID's by D. McGuire								

MACROINVERTEBRATE DATA

BLACKFOOT RIVER at Nevada-Ogden Rd. Br. - STATION 6 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
COLEOPTERA						4%	27	
Optioservus spp.	27	30	32	14	103	4%	25.8	8.1
Zaitzevia parvula	0	2	0	1	3	0%	0.8	1.0
Narpus concolor	3	0	0	0	3	0%	0.8	1.5
DIPTERA						16%	114	
Pagastia sp	2	0	1	0	3	0%	0.8	1.0
Potthastia sp.	7	5	1	4	17	1%	4.3	2.5
Corynoneura sp	3	1	0	2	6	0%	1.5	1.3
Cricotopus spp.	32	26	5	14	77	3%	19.3	12.1
Eukiefferiella spp.	6	9	1	4	20	1%	5.0	3.4
Krenosmittia sp.	1	0	0	0	1	0%	0.3	0.5
Orthocladius spp.	2	3	1	4	10	0%	2.5	1.3
Nanocladius sp.	0	0	0	1	1	0%	0.3	0.5
Paraphaenocladius sp.	1	0	0	0	1	0%	0.3	0.5
Tvetenia sp.	11	14	8	1	34	1%	8.5	5.6
Polypedilum spp.	0	0	1	0	1	0%	0.3	0.5
Rheotanytarsus sp.	0	1	0	2	3	0%	0.8	1.0
Micropsectra spp.	33	54	35	60	182	6%	45.5	13.5
Antocha sp.	0	1	1	0	2	0%	0.5	0.6
Hexatoma sp.	25	5	7	3	40	1%	10.0	10.1
Atherix pachypus	2	0	1	0	3	0%	0.8	1.0
Simulium spp. (Eusimuluin	19	13	8	3	43	1%	10.8	6.8
Simulium sp. (Psilozia)	1	0	0	0	1	0%	0.3	0.5
Chelifera sp.	3	3	4	1	11	0%	2.8	1.3
EPHEMEROPTERA						59%	425	
Baetis insignificans	124	152	119	73	468	16%	117.0	32.7
Baetis tricaudatus	29	84	118	29	260	9%	65.0	43.8
Attenella margarita	21	1	3	2	27	1%	6.8	9.5
Serratella spp.	12	29	24	13	78	3%	19.5	8.3
Drunella doddsi	2	0	0	0	2	0%	0.5	1.0
Drunella grandis	13	5	3	0	21	1%	5.3	5.6
Timpango hecuba	2	0	0	0	2	0%	0.5	1.0
Cinygmula sp.	4	0	1	0	5	0%	1.3	1.9
Rhithrogena sp.	102	262	203	232	799	28%	199.8	69.5
Paraleptophlebia sp.	1	20	3	14	38	1%	9.5	9.0
PLECOPTERA						19%	137	
Claassenia sabulosa	0	6	4	7	17	1%	4.3	3.1
Hesperoperla pacifica	0	26	10	5	41	1%	10.3	11.3
Zapada cinctipes	1	4	7	3	15	1%	3.8	2.5
Skwala sp.	7	10	12	4	33	1%	8.3	3.5
Pteronarcella badia	1	8	8	0	17	1%	4.3	4.3
Chloroperlinae	17	124	146	138	425	15%	106.3	60.2

MACROINVERTEBRATE DATA

BLACKFOOT RIVER at Nevada-Ogden Rd. Br. - STATION 6 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
TRICHOPTERA						2%	14	
Arctopsyche grandis	3	10	8	5	26	1%	6.5	3.1
H. (Ceratopsyche) spp.?	0	2	2	0	4	0%	1.0	1.2
Apatania sp.	3	1	0	0	4	0%	1.0	1.4
Neophylx sp.	2	0	0	0	2	0%	0.5	1.0
Brachycentrus occidentalis	6	0	0	1	7	0%	1.8	2.9
Rhyacophila angelita sp.	1	0	0	0	1	0%	0.3	0.5
Glossosoma sp.	0	5	3	5	13	0%	3.3	2.4
ANNELIDA						0%	2	
Lumbriculidae	0	2	0	0	2	0%	0.5	1.0
Naididae	2	0	0	0	2	0%	0.5	1.0
Tubificidae	2	0	1	0	3	0%	0.8	1.0
MOLLUSCA						0%	0	
Sphaeriidae	1	0	0	0	1	0%	0.3	0.5
OTHER								
Turbellaria	0	1	1	1	3	0%	0.8	0.5
TOTAL ORGANISMS	534	919	782	646	2881		720	167
TAXA RICHNESS	39	33	33	29	50		34	4.1
SHAN. DIVERSITY	3.92	3.49	3.28	3.04	3.58		3.43	0.37
BIOTICINDEX	3.72	2.95	2.87	2.52	2.98		3.02	0.51
EPT RICHNESS	19	17	17	14	23		17	2.1
EPT / CHIR.	3.58	6.63	12.72	5.77	6.47		7.2	3.9
% R.A. DOMINANT	23%	29%	26%	36%	28%		28%	5.5%
% R.A. FILTERERS	5%	3%	2%	2%	3%		3%	1.6%
ID's by D. McGuire								

MACROINVERTEBRATE DATA

BLACKFOOT RIVER at Helmville Bridge - STATION 7 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
COLEOPTERA						11%	458	
Optioservus spp.	108	68	216	68	460	3%	115.0	69.9
Zaitzevia parvula	6	16	12	16	50	0%	12.5	4.7
Cleptelmis ornata	268	328	360	344	1300	8%	325.0	40.2
Dubiraphia sp.	0	8	8	4	20	0%	5.0	3.8
Staphylinidae	1	0	0	0	1	0%	0.3	0.5
DIPTERA						18%	751	
Thienemannimyia gp.	52	36	52	68	208	1%	52.0	13.1
Pentaneura sp.	10	12	16	24	62	0%	15.5	6.2
Pagastia sp	4	4	0	0	8	0%	2.0	2.3
Corynoneura sp	4	0	4	0	8	0%	2.0	2.3
Cricotopus spp.	50	12	26	24	112	1%	28.0	15.9
Eukiefferiella spp.	6	4	28	4	42	0%	10.5	11.7
Thienemanniella sp.	0	0	8	0	8	0%	2.0	4.0
Orthocladius spp.	6	4	10	4	24	0%	6.0	2.8
Paraphaenocladius sp.	10	0	12	10	32	0%	8.0	5.4
Tvetenia sp.	210	60	242	66	578	3%	144.5	95.0
Cryptochironomus sp.	0	0	0	2	2	0%	0.5	1.0
Polypedilum spp.	0	4	4	6	14	0%	3.5	2.5
Microtendipes sp	0	0	4	12	16	0%	4.0	5.7
Phaenopsectra sp	2	1	8	4	15	0%	3.8	3.1
Tanytarsus sp. (Sublettea)	12	8	20	0	40	0%	10.0	8.3
Micropsectra spp.	6	12	58	16	92	1%	23.0	23.7
Hexatoma sp.	1	3	2	6	12	0%	3.0	2.2
Tipula sp.	1	1	0	4	6	0%	1.5	1.7
Tipulidae	1	0	0	0	1	0%	0.3	0.5
Simulium spp. (Eusimuluin	114	56	164	38	372	2%	93.0	57.4
Simulium sp. (Psilozia)	270	348	560	170	1348	8%	337.0	165.6
Odontomyia sp.	0	0	1	0	1	0%	0.3	0.5
Chelifera sp.	2	0	0	0	2	0%	0.5	1.0
EPHEMEROPTERA						39%	1626	
Baetis insignificans	30	0	4	0	34	0%	8.5	14.5
Baetis tricaudatus	656	640	1240	616	3152	19%	788.0	301.8
Psuedocloeon sp.	48	116	208	70	442	3%	110.5	70.9
Attenella margarita	106	120	196	104	526	3%	131.5	43.6
Serratella tibialis	20	24	4	28	76	0%	19.0	10.5
Ephemerella inermis	4	4	8	6	22	0%	5.5	1.9
Drunella grandis	14	0	32	10	56	0%	14.0	13.4
Heptagenia soltari	20	4	32	2	58	0%	14.5	14.2
Nixe sp.	0	0	0	4	4	0%	1.0	2.0
Rhithrogena sp.	4	8	20	16	48	0%	12.0	7.3
Paraleptophlebia bicornuta	40	2	18	46	106	1%	26.5	20.3
Ehemera simulans (?)	3	2	5	0	10	0%	2.5	2.1
Tricorythodes minutus	266	352	868	484	1970	12%	492.5	265.9

MACROINVERTEBRATE DATA

BLACKFOOT RIVER at Helmville Bridge - STATION 7 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
HEMIPTERA								
Macrovelia sp.	1	0	0	0	1	0%	0.3	0.5
LEPIDOPTERA								
Petrophila sp.	0	0	0	1	1	0%	0.3	0.5
ODONATA								
Ophiogomphus sp.	2	4	10	5	21	0%	5.3	3.4
PLECOPTERA						1%	29	
Claassenia sabulosa	2	0	1	2	5	0%	1.3	1.0
Hesperoperla pacifica	17	8	14	22	61	0%	15.3	5.9
Zapada cinctipes	4	0	0	0	4	0%	1.0	2.0
Perlodidae	4	0	0	0	4	0%	1.0	2.0
Pteronarcella badia	6	4	7	4	21	0%	5.3	1.5
Pteronarcys californica	4	0	1	4	9	0%	2.3	2.1
Isoperla sp.	2	2	0	0	4	0%	1.0	1.2
Chloroperlinae	6	1	0	1	8	0%	2.0	2.7
TRICHOPTERA						27%	1143	
Arctopsyche grandis	1	0	1	4	6	0%	1.5	1.7
Cheumatopsyche spp.	428	272	804	716	2220	13%	555.0	247.7
Hydropsyche occidentalis	20	16	36	50	122	1%	30.5	15.6
H. (Ceratopsyche) spp.?	386	188	684	518	1776	11%	444.0	209.7
Hydroptila spp.	0	1	20	2	23	0%	5.8	9.5
Oecetis sp.	0	4	8	4	16	0%	4.0	3.3
Wormaldia sp.	2	0	0	0	2	0%	0.5	1.0
Brachycentrus occidentalis	34	80	192	74	380	2%	95.0	67.8
Culoptila sp	0	8	12	0	20	0%	5.0	6.0
Helicopsyche sp	1	0	4	0	5	0%	1.3	1.9
ANNELIDA						4%	166	
Erobdellidae	1	0	0	0	1	0%	0.3	0.5
Lumbricidae	3	0	1	1	5	0%	1.3	1.3
Tubificidae	136	436	16	68	656	4%	164.0	187.9
MOLLUSCA						0%	2	
Sphaeriidae	6	0	0	0	6	0%	1.5	3.0
TOTAL ORGANISMS	3421	3281	6261	3752	16715		4179	1402
TAXA RICHNESS	55	42	50	47	66		49	5.4
SHAN. DIVERSITY	3.98	3.74	3.79	3.74	3.92		3.81	0.11
BIOTIC INDEX	4.77	5.17	4.51	4.51	4.69		4.74	0.31
EPT RICHNESS	27	21	25	23	31		24	2.6
EPT / CHIR.	5.72	11.82	8.98	11.61	8.87		9.5	2.9
% R.A. DOMINANT	19%	20%	20%	19%	19%		19%	0.3%
% R.A. FILTERERS	37%	29%	39%	42%	37%		37%	5.4%
ID's by D. McGuire								

MACROINVERTEBRATE DATA

BLACKFOOT RIVER above Monture Cr. - STATION 8 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
COLEOPTERA						11%	136	
Optioservus spp.	84	227	94	92	497	10%	124.3	68.6
Zaitzevia parvula	10	17	9	5	41	1%	10.3	5.0
Cleptelmis ornata	1	0	0	2	3	0%	0.8	1.0
Oreodytes spp.	0	0	1	0	1	0%	0.3	0.5
DIPTERA						36%	444	
unassociated midge pupa	5	3	2	3	13	0%	3.3	1.3
Thienemannimyia gp.	5	26	12	18	61	1%	15.3	8.9
Pentaneura sp.	0	0	1	0	1	0%	0.3	0.5
Monodiamesa sp.	0	0	0	1	1	0%	0.3	0.5
Pagastia sp	4	5	8	15	32	1%	8.0	5.0
Potthastia sp.	0	0	1	0	1	0%	0.3	0.5
Corynoneura sp	1	4	6	12	23	0%	5.8	4.6
Cricotopus spp.	9	24	16	66	115	2%	28.8	25.6
Eukiefferiella spp.	0	0	1	0	1	0%	0.3	0.5
Nanocladius sp.	0	2	1	0	3	0%	0.8	1.0
Thienemanniella sp.	0	0	0	1	1	0%	0.3	0.5
Paraphaenocladius sp.	1	1	0	0	2	0%	0.5	0.6
Tvetenia sp.	12	10	12	8	42	1%	10.5	1.9
Polypedilum spp.	0	4	5	4	13	0%	3.3	2.2
Microtendipes sp	6	48	34	74	162	3%	40.5	28.3
Phaenopsectra sp	0	6	8	4	18	0%	4.5	3.4
Tanytarsus sp. (Sublettea)	24	178	64	212	478	10%	119.5	89.8
Rheotanytarsus sp.	4	2	0	6	12	0%	3.0	2.6
Micropsectra spp.	222	209	90	181	702	14%	175.5	59.5
Antocha sp.	3	11	1	6	21	0%	5.3	4.3
Hexatoma sp.	10	8	4	3	25	1%	6.3	3.3
Rhabdomastix sp.	0	0	0	1	1	0%	0.3	0.5
Atherix pachypus	1	1	1	0	3	0%	0.8	0.5
Simulium spp. (Eusimuluin	4	6	1	2	13	0%	3.3	2.2
Chelifera sp.	8	17	3	5	33	1%	8.3	6.2
EPHEMEROPTERA						25%	316	
Baetis insignificans	42	54	55	44	195	4%	48.8	6.7
Baetis tricaudatus	210	219	137	87	653	13%	163.3	62.7
Attenella margarita	13	10	7	20	50	1%	12.5	5.6
Serratella tibialis	48	38	33	24	143	3%	35.8	10.0
Drunella doddsi	0	1	1	0	2	0%	0.5	0.6
Drunella grandis	8	16	4	6	34	1%	8.5	5.3
Timpango hecuba	1	0	3	0	4	0%	1.0	1.4
Epeorus albertae	0	3	2	0	5	0%	1.3	1.5
Heptagenia soltari	0	0	1	0	1	0%	0.3	0.5
Nixe sp.	6	16	6	11	39	1%	9.8	4.8
Rhithrogena sp.	6	16	6	11	39	1%	9.8	4.8
Paraleptophlebia bicornuta	0	2	2	3	7	0%	1.8	1.3
Tricorythodes minutus	14	21	30	26	91	2%	22.8	6.9

MACROINVERTEBRATE DATA

BLACKFOOT RIVER above Monture Cr. - STATION 8 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
HEMIPTERA								
Saldidae	1	0	0	0	1	0%	0.3	0.5
PLECOPTERA						3%	34	
Claassenia sabulosa	4	1	3	3	11	0%	2.8	1.3
Hesperoperla pacifica	0	5	6	1	12	0%	3.0	2.9
Skwala parallela	2	9	2	5	18	0%	4.5	3.3
Pteronarcys californica	12	22	17	6	57	1%	14.3	6.8
Chloroperlinae	14	12	5	5	36	1%	9.0	4.7
TRICHOPTERA						24%	294	
Arctopsyche grandis	22	17	6	11	56	1%	14.0	7.0
Cheumatopsyche spp.	63	121	46	75	305	6%	76.3	32.1
Hydropsyche occidentalis	0	2	0	0	2	0%	0.5	1.0
Hydropsyche cockerelli	58	78	27	63	226	5%	56.5	21.4
H. (Ceratopsyche) spp.?	116	144	54	78	392	8%	98.0	39.9
Dicosmoecus sp.	0	0	0	1	1	0%	0.3	0.5
Neophylx sp.	0	0	0	2	2	0%	0.5	1.0
Hydroptila spp.	0	0	0	1	1	0%	0.3	0.5
Lepidostoma sp.	1	0	0	0	1	0%	0.3	0.5
Ceraclea sp.	1	1	2	0	4	0%	1.0	0.8
Oecetis sp.	4	3	1	2	10	0%	2.5	1.3
Psychomyia flavida	14	51	24	66	155	3%	38.8	24.0
Brachycentrus occidentalis	5	2	5	0	12	0%	3.0	2.4
Rhyacophila angelita sp.	0	1	0	0	1	0%	0.3	0.5
Rhyacophila sp.	2	1	0	0	3	0%	0.8	1.0
Helicopsyche sp	0	4	0	1	5	0%	1.3	1.9
ANNELIDA						2%	22	
Glossophonidae	0	1	1	1	3	0%	0.8	0.5
Lumbriculidae	0	0	0	1	1	0%	0.3	0.5
Tubificidae	20	14	17	31	82	2%	20.5	7.4
MOLLUSCA						0%	1	
Physa sp.	0	0	0	3	3	0%	0.8	1.5
Lymnaea sp.	0	0	1	0	1	0%	0.3	0.5
Sphaeriidae	0	0	1	0	1	0%	0.3	0.5
OTHER								
Turbellaria	1	3	2	0	6	0%	1.5	1.3
TOTAL ORGANISMS	1102	1697	882	1309	4990		1248	347
TAXA RICHNESS	45	52	54	50	71		50	3.9
SHAN. DIVERSITY	3.98	4.23	4.45	4.30	4.35		4.24	0.20
BIOTICINDEX	4.85	4.89	4.83	5.21	4.95		4.94	0.18
EPT RICHNESS	23	28	26	24	34		25	2.2
EPT / CHIR.	2.27	1.67	1.86	0.91	1.53		1.7	0.6
% R.A. DOMINANT	20%	13%	16%	16%	14%		16%	2.8%
% R.A. FILTERERS	25%	22%	16%	18%	20%		20%	4.0%

MACROINVERTEBRATE DATA

BLACKFOOT RIVER below Scotty Brown Bridge - STATION 9 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
COLEOPTERA						4%	54	
Optioservus spp.	29	52	50	23	154	3%	38.5	14.7
Zaitzevia parvula	20	16	14	6	56	1%	14.0	5.9
Cleptelmis ornata	0	1	0	5	6	0%	1.5	2.4
DIPTERA						35%	501	
unassociated midge pupa	1	3	0	1	5	0%	1.3	1.3
Thienemannimyia gp.	1	0	0	0	1	0%	0.3	0.5
Diamesa spp.	0	0	1	1	2	0%	0.5	0.6
Pagastia sp	3	0	1	1	5	0%	1.3	1.3
Cardiocladius spp.	3	15	2	21	41	1%	10.3	9.3
Cricotopus spp.	4	19	15	15	53	1%	13.3	6.4
Eukiefferiella spp.	5	8	12	11	36	1%	9.0	3.2
Nanocladius sp.	2	0	0	0	2	0%	0.5	1.0
Paraphaenocladius sp.	0	0	1	0	1	0%	0.3	0.5
Synorthocladius sp.	0	0	0	3	3	0%	0.8	1.5
Tvetenia sp.	25	14	11	9	59	1%	14.8	7.1
Polypedilum spp.	0	0	0	1	1	0%	0.3	0.5
Phaenopsectra sp	1	0	0	0	1	0%	0.3	0.5
Tanytarsus sp. (Sublettea)	4	0	0	3	7	0%	1.8	2.1
Rheotanytarsus sp.	0	1	0	1	2	0%	0.5	0.6
Micropsectra spp.	47	115	18	91	271	5%	67.8	43.5
Antocha sp.	0	0	3	0	3	0%	0.8	1.5
Hexatoma sp.	8	32	11	21	72	1%	18.0	10.9
Ceratopogoninae	1	2	0	0	3	0%	0.8	1.0
Atherix pachypus	13	7	7	14	41	1%	10.3	3.8
Simulium spp. (Eusimuluin	28	219	8	1127	1382	24%	345.5	529.6
Simulium sp. (Psilozia)	0	0	0	3	3	0%	0.8	1.5
Chelifera sp.	3	1	4	3	11	0%	2.8	1.3
EPHEMEROPTERA						36%	521	
Baetis insignificans	37	62	48	49	196	3%	49.0	10.2
Baetis tricaudatus	268	398	344	411	1421	25%	355.3	65.0
Attenella margarita	1	0	0	1	2	0%	0.5	0.6
Serratella tibialis	35	71	33	63	202	4%	50.5	19.3
Ephemerella inermis	0	1	0	1	2	0%	0.5	0.6
Drunella coloradensis	0	0	0	2	2	0%	0.5	1.0
Drunella doddsi	3	16	17	17	53	1%	13.3	6.8
Drunella grandis	4	1	5	2	12	0%	3.0	1.8
Epeorus albertae	0	0	3	0	3	0%	0.8	1.5
Rhithrogena sp.	22	63	42	56	183	3%	45.8	18.1
Tricorythodes minutus	2	0	4	1	7	0%	1.8	1.7

MACROINVERTEBRATE DATA

BLACKFOOT RIVER below Scotty Brown Bridge - STATION 9 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
PLECOPTERA						3%	48	
Calineuria californica	0	4	2	2	8	0%	2.0	1.6
Claassenia sabulosa	2	2	1	3	8	0%	2.0	0.8
Hesperoperla pacifica	2	5	2	1	10	0%	2.5	1.7
Zapada sp.	0	1	1	0	2	0%	0.5	0.6
Perlodidae	2	0	0	1	3	0%	0.8	1.0
Pteronarcella badia	0	2	1	3	6	0%	1.5	1.3
Pteronarcys californica	19	10	12	6	47	1%	11.8	5.4
Chloroperlinae	27	47	15	17	106	2%	26.5	14.6
TRICHOPTERA						22%	318	
Arctopsyche grandis	17	4	8	8	37	1%	9.3	5.5
Cheumatopsyche spp.	7	3	3	9	22	0%	5.5	3.0
Hydropsyche cockerelli	74	33	22	39	168	3%	42.0	22.5
H. (Ceratopsyche) spp.?	276	230	158	313	977	17%	244.3	66.8
Oecetis sp.	0	0	0	1	1	0%	0.3	0.5
Psychomyia flavida	2	0	1	0	3	0%	0.8	1.0
Micrasema sp.	0	1	0	2	3	0%	0.8	1.0
Brachycentrus occidentalis	21	3	9	24	57	1%	14.3	9.9
Rhyacophila sp.	0	1	1	1	3	0%	0.8	0.5
ANNELIDA						0%	1	
Lumbriculidae	0	4	0	1	5	0%	1.3	1.9
TOTAL ORGANISMS	1019	1467	890	2394	5770		1443	681
TAXA RICHNESS	37	37	37	46	55		39	4.5
SHAN. DIVERSITY	3.52	3.53	3.38	2.78	3.44		3.30	0.35
BIOTICINDEX	4.20	4.29	4.04	4.57	4.35		4.28	0.22
EPT RICHNESS	19	21	22	25	28		22	2.5
EPT / CHIR.	8.55	5.47	12.00	6.54	7.23		8.1	2.9
% R.A. DOMINANT	27%	27%	39%	47%	25%		35%	9.7%
% R.A. FILTERERS	42%	34%	23%	64%	46%		41%	17.1%
ID's by D. McGuire								

MACROINVERTEBRATE DATA

BLACKFOOT RIVER at Ninemile Praire - STATION 12 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
COLEOPTERA						5%	35	
Optioservus spp.	18	28	18	28	92	3%	23.0	5.8
Zaitzevia parvula	12	8	13	11	44	2%	11.0	2.2
Stenelmis sp.	1	0	0	0	1	0%	0.3	0.5
Herteroceridae	0	1	0	0	1	0%	0.3	0.5
DIPTERA						19%	137	
unassociated midge pupa	2	5	4	5	16	1%	4.0	1.4
Thienemannimyia gp.	0	1	0	0	1	0%	0.3	0.5
Diamesa spp.	1	0	0	0	1	0%	0.3	0.5
Pagastia sp	1	0	0	0	1	0%	0.3	0.5
Potthastia sp.	1	4	2	0	7	0%	1.8	1.7
Cardiocladius spp.	3	1	0	1	5	0%	1.3	1.3
Corynoneura sp	0	13	7	8	28	1%	7.0	5.4
Cricotopus spp.	2	21	12	6	41	1%	10.3	8.3
Eukiefferiella spp.	2	8	6	7	23	1%	5.8	2.6
Krenosmittia sp.	0	1	0	0	1	0%	0.3	0.5
Paraphaenocladius sp.	0	1	0	1	2	0%	0.5	0.6
Synorthocladius sp.	1	1	2	0	4	0%	1.0	0.8
Tvetenia sp.	3	6	2	5	16	1%	4.0	1.8
Polypedilum spp.	8	22	19	9	58	2%	14.5	7.0
Microtendipes sp	1	1	0	0	2	0%	0.5	0.6
Tanytarsus sp.(Sublettea)	4	5	3	4	16	1%	4.0	0.8
Rheotanytarsus sp.	1	3	1	0	5	0%	1.3	1.3
Micropsectra spp.	40	82	20	48	190	7%	47.5	25.8
Antocha sp.	0	1	1	0	2	0%	0.5	0.6
Hexatoma sp.	3	3	3	3	12	0%	3.0	0.0
Atherix pachypus	1	1	0	2	4	0%	1.0	0.8
Simulium spp. (Eusimuluin	74	18	10	5	107	4%	26.8	32.0
Simulium sp. (Psilozia)	3	0	0	0	3	0%	0.8	1.5
Ceratopogoninae	0	0	1	0	1	0%	0.3	0.5
Chelifera sp.	1	1	0	0	2	0%	0.5	0.6
EPHEMEROPTERA						41%	294	
Baetis insignificans	33	148	67	89	337	12%	84.3	48.3
Baetis tricaudatus	191	221	99	148	659	23%	164.8	53.1
Attenella margarita	0	4	1	2	7	0%	1.8	1.7
Serratella tibialis	5	6	2	6	19	1%	4.8	1.9
Drunella doddsi	6	2	2	4	14	0%	3.5	1.9
Drunella grandis	0	0	0	1	1	0%	0.3	0.5
Epeorus albertae	1	3	0	4	8	0%	2.0	1.8
Rhithrogena sp.	24	37	31	32	124	4%	31.0	5.4
Tricorythodes minutus	2	1	1	1	5	0%	1.3	0.5
LEPIDOPTERA								
Petrophila sp.	3	6	11	12	32	1%	8.0	4.2

MACROINVERTEBRATE DATA

BLACKFOOT RIVER at Ninemile Praire - STATION 12 - 8/10/89

Taxon	sample1	sample2	sample3	sample4	SUM	%RA	MEAN	S. D.
PLECOPTERA						7%	50	
Calineuria californica	12	18	16	21	67	2%	16.8	3.8
Claassenia sabulosa	0	1	0	1	2	0%	0.5	0.6
Hesperoperla pacifica	1	1	0	1	3	0%	0.8	0.5
Skwala parallela	4	4	3	9	20	1%	5.0	2.7
Pteronarcys californica	20	28	17	34	99	3%	24.8	7.7
Chloroperlinae	0	3	1	4	8	0%	2.0	1.8
TRICHOPTERA						27%	193	
Arctopsyche grandis	27	41	20	19	107	4%	26.8	10.1
Cheumatopsyche spp.	20	39	21	41	121	4%	30.3	11.3
Hydropsyche occidentalis	2	1	1	2	6	0%	1.5	0.6
Hydropsyche cockerelli	53	48	30	38	169	6%	42.3	10.3
H. (Ceratopsyche) spp.?	39	57	46	29	171	6%	42.8	11.8
Lepidostoma sp.	0	4	4	0	8	0%	2.0	2.3
Oecetis sp.	0	1	1	0	2	0%	0.5	0.6
Psychomyia flavida	1	3	5	5	14	0%	3.5	1.9
Brachycentrus occidentalis	46	45	33	44	168	6%	42.0	6.1
Rhyacophila angelita sp.	0	0	0	1	1	0%	0.3	0.5
Rhyacophila sp.	0	0	1	0	1	0%	0.3	0.5
Culoptila sp	0	2	1	0	3	0%	0.8	1.0
Glossosoma sp.	0	1	0	0	1	0%	0.3	0.5
ANNELIDA						0%	1	
Tubificidae	1	1	0	0	2	0%	0.5	0.6
OTHER								
Turbellaria	1	0	0	2	3	0%	0.8	1.0
TOTAL ORGANISMS	675	962	538	693	2868		717	177
TAXA RICHNESS	43	51	40	40	60		44	5.2
SHAN. DIVERSITY	3.88	4.08	4.26	4.16	4.19		4.10	0.16
BIOTIC INDEX	4.02	4.38	4.10	4.09	4.17		4.15	0.16
EPT RICHNESS	18	25	22	23	28		22	2.9
EPT / CHIR.	6.96	4.11	5.17	5.70	5.14		5.5	1.2
% R.A. DOMINANT	28%	23%	18%	21%	23%		23%	4.1%
% R.A. FILTERERS	39%	26%	30%	26%	30%		30%	6.3%
ID's by D. McGuire								

C.1 Analysis of Variance and multiple range tests of total macroinvertebrate densities at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	58784732.10	5	11756946.42	4.04	0.005
Between year	11500313.02	1	11500313.02	3.95	0.058
Interaction	34475584.60	5	6895116.92	2.37	0.059
Error	104855319.25	36	2912647.76		
Total	209615948.98	47			

Newman-Keuls test (location n = 8, year n = 24)
underscored values are not significantly different at P=< 0.05.

station:	6	12	8	9	4	7
mean:	687	850	1535	2514	3110	3614
	———	———	———	———	———	
			———	———	———	———

year:	1988	1989
mean:	2541	1562
	———	———

C.1 (continued) Analysis of Variance and multiple range tests of transformed (ln x) total macroinvertebrate densities at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	13.82	5	2.76	10.76	0.000
Between year	1.55	1	1.55	6.04	0.019
Interaction	4.88	5	0.98	3.80	0.007
Error	9.24	36	0.26		
Total	29.49	47			

Newman-Keuls test (location n = 8, year n = 24)
underscored values are not significantly different at P=< 0.05.

station:	6	12	8	9	4	7
mean:(ln x)	6.5	6.7	7.3	7.8	8.0	8.2
	———	———		———	———	———
			———	———		

year:	1988	1989
mean:	7.8	7.4

(significantly different at P = 0.05)

C.2 Analysis of Varience and multiple range tests of macroinvertebrate taxa richness at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	766.75	5	153.35	10.37	0.000
Between year	481.33	1	481.33	32.54	0.000
Interaction	318.67	5	63.73	4.31	0.004
Error	532.50	36	14.79		
Total	2099.25	47			

Newman-Keuls test (location n = 8, year n = 24)
$\underline{\text{underscored}}$ values are not significantly different at P=< 0.05.

station: 6 4 9 12 7 8
mean: $\underline{33.4 \quad 34.5 \quad 36.4}$ $\underline{42.0 \quad 42.1 \quad 43.4}$

year: 1988 1989
mean: 35.8 41.8
(significantly differenct at P = 0.05.)

C.3 Analysis of Varience and multiple range tests of Shannon diversity at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	10.03	5	2.01	16.25	0.000
Between year	4.80	1	4.80	38.91	0.000
Interaction	4.10	5	0.82	6.65	0.000
Error	4.44	36	0.12		
Total	23.37	47			

Newman-Keuls test (location n = 8, year n = 24)
underscored values are not significantly different at P=< 0.05.

station: 4 9 6 7 8 12
mean: 2.7 $\underline{3.2 \quad 3.3 \quad 3.5}$ $\underline{3.9 \quad 4.0}$

year: 1988 1989
mean: 3.12 3.75
(significantly differenct at P = 0.05.)

C.4 Analysis of Variance and multiple range tests of the biotic index at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	26.56	5	5.31	51.26	0.000
Between year	2.34	1	2.34	22.59	0.000
Interaction	8.26	5	1.65	15.94	0.000
Error	3.73	36	0.10		
Total	40.89	47			

Newman-Keuls test (location n = 8, year n = 24)
underscored values are not significantly different at P=< 0.05.

station:	6	12	4	9	8	7
mean:	2.7	4.3	4.5	4.7	4.9	4.9

year:	1988	1989
mean:	4.54	4.09

(significantly differenct at P = 0.05.)

C.5 Analysis of Variance and multiple range tests of EPT richness at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	125.35	5	25.07	5.02	0.001
Between year	93.52	1	93.52	18.73	0.000
Interaction	97.35	5	19.47	3.90	0.006
Error	179.75	36	4.99		
Total	495.98	47			

Newman-Keuls test (location n = 8, year n = 24)
underscored values are not significantly different at P=< 0.05.

station:	6	4	9	7	12	8
mean:	17.6	18.9	19.4	21.5	21.5	22.0

year:	1988	1989
mean:	18.75	21.54

(significantly differenct at P = 0.05.)

C.6 Analysis of Variance and multiple range tests of the percent relative abundance of the dominant taxon at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	4043.92	5	808.78	11.72	0.000
Between year	2214.08	1	2214.08	32.08	0.000
Interaction	2687.67	5	537.53	7.79	0.000
Error	2485.00	36	69.03		
Total	11430.67	47			

Newman-Keuls test (location n = 8, year n = 24)
underscored values are not significantly different at P=< 0.05.

station:	8	12	7	9	6	4
mean:	21.0	22.5	29.5	33.8	34.3	48.8

year:	1988	1989
mean:	38.5	24.7

(significantly differenct at P = 0.05.)

C.7 Analysis of Variance and multiple range tests of the percent relative abundance of filter feeding macroinvertebrates at six locations in the Blackfoot River during August, 1988 and 1989.

ANOVA

DataFile: BFRstats

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Between station	11119.35	5	2223.87	17.19	0.000
Between year	3120.19	1	3120.19	24.12	0.000
Interaction	2976.19	5	595.24	4.60	0.002
Error	4656.25	36	129.34		
Total	21871.98	47			

Newman-Keuls test (location n = 8, year n = 24)
underscored values are not significantly different at P=< 0.05.

station:	6	8	12	9	4	7
mean:	5.5	24.5	33.5	42.0	47.5	50.0

year:	1988	1989
mean:	41.7	25.8

(significantly differenct at P = 0.05.)

Appendix D. Community Similarity coefficients for six Blackfoot River stations during August, 1988 and 1989 (four square foot samples pooled at each station). Coefficients >= 50 are **bold.**

AUGUST, 1988

Station	4	6	7	8	9
4	-				
6	19	-			
7	26	20	-		
8	27	41	35	-	
9	**57**	38	35	**65**	-
12	23	29	30	**69**	**55**

AUGUST, 1989

Station	4	6	7	8	9
4	-				
6	38	-			
7	25	23	-		
8	35	37	43	-	
9	**57**	35	42	47	-
12	37	44	44	**53**	**60**

Between years (1988 vs 1989)

Station	
4	48
6	**69**
7	42
8	**61**
9	**76**
12	**68**